

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re application of:

Karl Littau, et al.

Application No.: 08/893,917

Filed: July 11, 1997

For: REMOTE PLASMA CLEANING  
SOURCE HAVING REDUCED  
REACTIVITY WITH A SUBSTRATE  
PROCESSING CHAMBER

Confirmation No. 8435

Examiner: Rudy Zervigon

Technology Center/Art Unit: 1792

APPELLANTS' BRIEF UNDER  
37 CFR §41.37

Mail Stop Appeal Brief  
Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Commissioner:

Further to the Notice of Panel Decision from Pre-Appeal Brief Review mailed on  
July 1, 2010 for the above-referenced application, Appellants submit this Brief on Appeal.

### **1. REAL PARTY IN INTEREST**

The real party in interest is Applied Materials, Inc.

### **2. RELATED APPEALS AND INTERFERENCES**

None.

### **3. STATUS OF CLAIMS**

Claims 22-24 and 27-28 are pending and appealed. Claims 1-21 and 25-26 were canceled.

### **4. STATUS OF AMENDMENTS**

No amendments were filed subsequent to the Final Office Action of March 26, 2010.

### **5. SUMMARY OF CLAIMED SUBJECT MATTER**

The claims of the present invention are directed to methods for removing cleaning a substrate processing chamber employing a remote plasma cleaning source.

During substrate processing operations, such as chemical vapor deposition (CVD) processes, unwanted deposition occurs within the substrate processing chamber that may interfere with the performance of the substrate processing system. Page 2, lines 9-23. In the past, it was common to remove the unwanted deposits by introducing etchant (cleaning) gases into the chamber and forming a plasma within the chamber (referred to as an *in situ* plasma cleaning process). Page 2, line 24 – page 3, line 4. Such *in situ* plasma cleaning often had the undesirable effect of damaging parts of the chamber during the cleaning process. Page 3, lines 7-11. As an alternative to *in situ* plasma cleaning processes, remote plasma cleaning processes were developed that formed the plasma in a location removed from the substrate processing chamber then transported the reactive radicals from the plasma to the substrate processing chamber to effect cleaning. Remote plasma cleaning processes were an improvement compared

to the *in situ* cleaning processes but may still damage the chamber or leave unwanted residue.  
Page 3, line 21 – page 4, line 3.

The invention of claim 22 pertains to a remote plasma chamber cleaning method that solves the problem associated with previous remote plasma clean processes by mixing a diluent gas with reactive radicals formed from the remote plasma at a location between the remote plasma chamber and the substrate processing chamber. Specifically, claim 22 recites a method of removing residue from a substrate processing chamber comprising the steps of: forming a plasma remotely with respect to said chamber, said plasma including a plurality of reactive radicals (see page 18, lines 13-17; see also plasma applicator 302 shown in Fig. 3; and see page 20, lines 8-9 as well as Fig. 4, step 342); forming a flow of said reactive radicals traversing toward said chamber (see page 18, lines 17-19; see also page 20, lines 9-10 and Fig. 4, step 344); forming a nonplasma diluent gas flow, wherein said nonplasma diluent gas flow comprises at least one of an inert gas or a reduction gas; mixing said flow of said reactive radicals and said diluent gas flow at a mixing location downstream of a location of forming said flow of said reactive radicals and anterior to said chamber to form a gas-radical mixture (see page 18, line 25 – 27; see also mixing chamber 322 which receives diluent gas from gas supply 326 and is located between plasma applicator 302 and substrate processing chamber 15; and see page 20, lines 10-14 and Fig. 4, steps 346 and 348); and flowing said gas-radical mixture into said chamber to remove residue from within said chamber, wherein each step of the method occurs without a wafer in said chamber (see page 18, lines 27-30; see also page 20, lines 14-15 and Fig. 4, step 349).

Claims 23-24 and 27-28 are dependent claims which depend from claim 22. Claim 23 recites that in the method of claim 22 the flow of reactive radicals and the gas flow are established to maintain a pressure within the chamber below one torr (see page 20, lines 27-29; see also page 31, original claim 2). Claim 24 recites that in the method of claim 22 the reactive radicals comprise atoms associated with a reactive gas, with said reactive gas being selected from a group consisting of  $\text{NF}_3$ , dilute  $\text{F}_2$ ,  $\text{CF}_4$ ,  $\text{C}_2\text{F}_6$ ,  $\text{C}_3\text{F}_8$ ,  $\text{SF}_6$ , and  $\text{ClF}_3$  (see page 21, lines 22-27; see also page 31, original claim 3). Claim 27 recites that in the method of claim 22 a subset of the radicals in the gas-radical mixture react with components creating a residue and that the

method further includes the step of exhausting the residue, with a rate at which the residue is exhausted depending upon a rate of the diluent gas flow (see page 19, line 25 to page 20, line 4; see also page 31, original claim 6). Claim 28 recites that in the method of claim 22 the diluent gas flow travels at a first rate and the flow of the reactive radicals travel at a second rate with a ratio of the first rate to the second rate being at least 2:1 (see page 20, lines 16-19).

## **6. GROUNDS OF REJECTION TO BE REVIEWED ON APPEAL**

The grounds of rejection to be reviewed on appeal are:

1) Whether claims 22-24 and 27-28 are obvious under 35 U.S.C. § 103(a) over Shang et al. (U.S. Patent 5,788,778) in view of Markunas et al. (U.S. Patent 5,018,479).

## **7. ARGUMENT**

The Final Office Action rejections claims 22-24 and 27-28 as being obvious under Section 103(a) in view of the combination of Shang et al. and Markunas et al. Essentially the Final Office Action states that Shang teaches every element of the invention of claim 22 except the particular gas composition of the claimed diluent gas and the Office Action argues that Markunas makes up for this deficiency. See Final Office Action dated March 26, 2010, pages 2-4, paragraph no. 3 (noting that Markunas teaches hydrogen as a reducing gas and it would be obvious to add hydrogen to Shang's "nonplasma diluent gas feed").

Contrary to what is stated in the Office Action, however, Shang does not teach several fundamental elements recited in claim 22. Specifically, claim 22 recites:

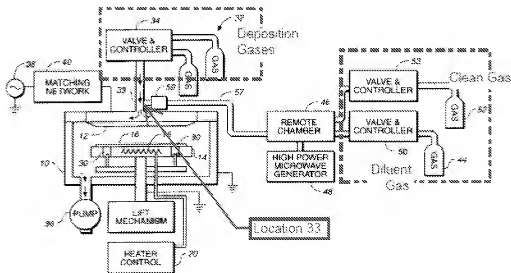
22. A method of removing residue from a substrate processing chamber, said method comprising the steps of:  
forming a plasma remotely with respect to said chamber, said plasma including a plurality of reactive radicals;  
forming a flow of said reactive radicals traversing toward said chamber;  
forming a nonplasma diluent gas flow, wherein said nonplasma diluent gas flow comprises at least one of an inert gas or a reduction gas;  
mixing said flow of said reactive radicals and said diluent gas flow at a mixing location downstream of a location of forming said flow

of said reactive radicals and anterior to said chamber to form a gas-radical mixture; and

flowing said gas-radical mixture into said chamber to remove residue from within said chamber,

wherein each step of the method occurs without a wafer in said chamber. (emphasis added)

The Office Action correctly notes that Shang teaches forming a remote plasma that is used for chamber cleaning in remote chamber 46. The Office Action is wrong, however, in stating that Shang teaches mixing the flow of reactive radicals with a diluent gas at “a mixing location downstream of a location of forming said flow of said reactive radicals and anterior to said chamber to form a gas-radical mixture” as required by claim 22. The Office Action believes that such mixing occurs at location 33 shown in Fig. 1, which is reproduced below and annotated for convenience.



Referring to the figure above, Shang et al. teaches that, during a substrate deposition operation, gases are introduced into chamber 10 from a first gas supply 32 of deposition gas sources (col. 4, lines 21-27). Then, after several deposition sequences are completed, Shang teaches that the chamber can be cleaned by flowing gases from a second gas supply (clean gas 52) into remote plasma chamber 46, forming a cleaning plasma in the remote

plasma chamber and transporting reactive cleaning radicals generated by the remote plasma to substrate processing chamber 10. Col. 4, lines 32-47.

Shang also teaches that a diluent gas (referred to in Shang as a “minor carrier gas”) can be added to the remote plasma clean process to aid in the transport of the activated species formed in remote plasma chamber 46 to the substrate processing chamber 10. Col. 4, line 64 to col. 5, line 8. Shang teaches that the diluent gas is added prior to the remote plasma chamber as shown by gas supply 44 in the figure above. Claim 22, however, requires that this mixing of a diluent gas and reactive radicals occurs downstream from where the reactive radicals are formed but prior to the substrate processing chamber. Therefore, Shang clearly does not teach this aspect of the invention of claim 22.

Moreover, combining Markunas with Shang does not make up for this deficiency. Markunas pertains to a method for growing epitaxial silicon, germanium and diamond layers on a substrate. As an initial matter, Markunas has absolutely nothing to do with removing unwanted deposits from substrate processing chamber or any form of a remote plasma chamber clean process. A person of ordinary skill in the art seeking to solve problems associated with remote plasma cleaning processes would not look to the field of growing epitaxial silicon, germanium and diamond layers for solutions. Accordingly, Applicants assert Markunas is nonanalogous art that cannot be properly combined with Shang.

Second, the manner in which Markunas and Shang have been combined smacks of impermissible hindsight and is generally contrary to the teaching of the references. The Section 103 rejection of claims 22-24 and 27-28 in view of Shang and Markunas is based on the following two premises set forth in the Office Action: (1) that a person of skill in the art would seek to add molecular hydrogen discussed in Markunas as the diluent gas used during the remote plasma clean process disclosed in Shang; and (2) that the molecular hydrogen from Markunas would be added to Shang via the deposition gas source 32 and mixed with radicals from the remote plasma clean gas at intersection 33 downstream of the remote plasma source 46 instead of being introduced directly into remote plasma source 46 via diluent gas source 44 as specifically taught by Shang. The Office Action’s logic underlying each of these premises, both of which must be relied upon to reach the Section 103 rejection, is faulty as discussed below.

The Office Action states that a person of skill in the art would be motivated to “add hydrogen to Shang’s ‘nonplasma’ diluent gas feed as taught by Markunas for ‘moderating the gas phase chemistry’ as taught by Markunas (column 8, lines 45-50).” The section of Markunas relied upon for this assertion, however, discusses adding molecular hydrogen to a diamond epitaxial growth process so that the hydrogen serves as a source of nucleation for the deposition reaction and so that it moderates the gas phase chemistry promoting higher saturation of  $\text{CH}_x$  radicals. Col. 8, lines 43-49. Nothing in either Markunas or Shang suggest that either of these issues is at all relevant to a remote plasma chamber clean process or that it a person of skill in the art would find it desirable to modify the surface chemistry of a chamber clean process as concluded in the Office Action. Obviousness cannot be established by combining the teaching of the prior art to produce the claimed invention, absent some teaching or suggestion supporting the combination. Absent sufficient and proper motivation for the combination, a *prima facie* case of obviousness cannot be established.

Moreover, even if the motivation set forth in the Office Action is sufficient, which Applicants do not believe, the Office Action has not established why the combination of Markunas and Shang would add the hydrogen diluent gas taught by Markunas to the clean gas in Shang from the deposition gas side of the Shang chamber (deposition gas 32) instead of from diluent gas 44 as specifically taught by Shang – a location prior to remote plasma chamber 46. Shang, col. 4, line 64 to col. 5, line 8. To the extent a person of skill in the art would add the molecular hydrogen diluent of Markunas to Shang, he or she would do so in accordance with the teaching by Shang – via gas supply 44 which feeds directly into the remote plasma chamber. Claim 22 is patentable over such a combination as the combination does not result in mixing of a diluent gas and reactive radicals downstream from where the reactive radicals are formed as required by claim 22.

Adding a diluent to Shang at a location other than that taught by Shang is contrary to its teaching and no motivation has been provided as to why a skilled artisan would contradict the teaching of Shang on this issue. The motivation the Examiner has provided for the combination, to “modify the surface chemistry” is irrelevant to the issue of the location at which diluent is introduced. Indeed,  $\text{H}_2$  can be added to Shang from diluent gas supply 44 prior to the

remote plasma chamber and still “modify the surface chemistry”. Accordingly, absent some clear reason to modify Shang in a manner contrary to its teaching as has been done in the Office Action, Appellants respectfully assert that the rejection of claim 22 is improper and should be withdrawn

Finally, even assuming *arguendo* that Markunas and Shang are properly combined, which for the reasons discussed above Applicants strongly disagree, the combination still does not result in the invention of claim 22. Markunas teaches that molecular hydrogen can be introduced anterior to a remote plasma chamber by introducing it directly into the substrate processing chamber. See col. 7, lines 53-56 and col. 8, lines 18-22 noting that hydrogen is introduced into the chamber through gas dispersal ring 18; see also Fig. 2 showing gas dispersal ring 18 within the deposition chamber). Thus, even if Markunas and Shang are combined in the manner done so in the Office Action, the combination would mix the reactive radicals and diluent directly in the chamber and not result in mixing reactive radicals with a diluent between the remote plasma chamber and substrate processing chamber as required by claim 22.

Applicants respectfully assert that claim 22, and its dependents, are all allowable over the cited art for all of the reasons above.

## **8. CONCLUSION**

For these reasons, it is respectfully submitted that the rejection should be reversed.

Respectfully submitted,

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## **9. CLAIMS APPENDIX**

1.-21. (Canceled)

22. (Previously Presented) A method of removing residue from a substrate processing chamber, said method comprising the steps of:

forming a plasma remotely with respect to said chamber, said plasma including a plurality of reactive radicals;

forming a flow of said reactive radicals traversing toward said chamber;

forming a nonplasma diluent gas flow, wherein said nonplasma diluent gas flow comprises at least one of an inert gas or a reduction gas;

mixing said flow of said reactive radicals and said diluent gas flow at a mixing location downstream of a location of forming said flow of said reactive radicals and anterior to said chamber to form a gas-radical mixture; and

flowing said gas-radical mixture into said chamber to remove residue from within said chamber,

wherein each step of the method occurs without a wafer in said chamber.

23. (Previously Presented) The method as recited in claim 22 wherein said flow of reactive radicals and said gas flow are established to maintain a pressure within said chamber below one torr.

24. (Previously Presented) The method as recited in claim 22 wherein said reactive radicals comprise atoms associated with a reactive gas, with said reactive gas being selected from a group consisting of  $\text{NF}_3$ , dilute  $\text{F}_2$ ,  $\text{CF}_4$ ,  $\text{C}_2\text{F}_6$ ,  $\text{C}_3\text{F}_8$ ,  $\text{SF}_6$ , and  $\text{ClF}_3$ .

25.-26. (Canceled)

27. (Previously Presented) The method as recited in claim 22 wherein said chamber has components therein, with a subset of said radicals in said gas-radical mixture reacting with said components creating a residue and further including the step of exhausting

said residue, with a rate at which said residue is exhausted depending upon a rate of said diluent gas flow.

28. (Previously Presented) The method as recited in claim 22 wherein said diluent gas flow travels at a first rate and said flow of said reactive radicals travel at a second rate with a ratio of said first rate to said second rate being at least 2:1.

**10. EVIDENCE APPENDIX**

None.

**11. RELATED PROCEEDINGS APPENDIX**

None.